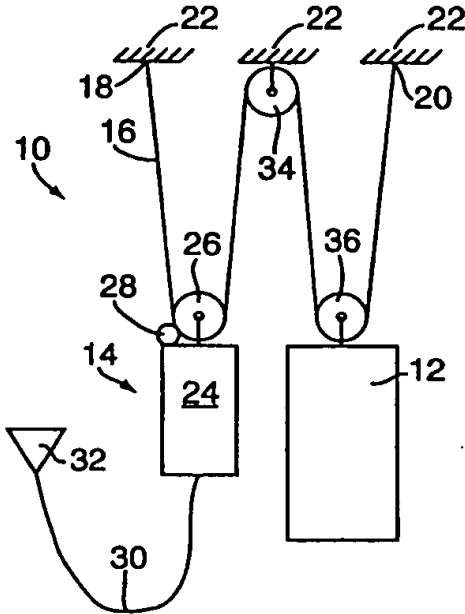


PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>6</sup> : <b>B66B 17/12, 11/08</b></p>	<p><b>A1</b></p>	<p>(11) International Publication Number: <b>WO 99/43602</b> (43) International Publication Date: <b>2 September 1999 (02.09.99)</b></p>
<p>(21) International Application Number: <b>PCT/US99/03647</b> (22) International Filing Date: <b>19 February 1999 (19.02.99)</b>  (30) Priority Data: 09/031,108 26 February 1998 (26.02.98) US 09/163,587 30 September 1998 (30.09.98) US 09/218,990 22 December 1998 (22.12.98) US  (71) Applicant: OTIS ELEVATOR COMPANY [US/US]; 10 Farm Springs, Farmington, CT (US). (72) Inventor: MONCINI, Ray; 164 Wild Oak Drive, Southington, CT 06489 (US). (74) Agent: HENLEY, Randy; Otis Elevator Company, Intellectual Property Dept., 10 Farm Springs, Farmington, CT 06032 (US).</p>		<p>(81) Designated States: BR, CN, IN, JP, KR, RU, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: <b>BELT-CLIMBING ELEVATOR HAVING DRIVE IN COUNTERWEIGHT AND COMMON DRIVE AND SUSPENSION ROPE</b></p>		
<p>(57) Abstract</p> <p>An elevator system includes a counterweight-drive assembly (24) having a motor and drive pulley (26) mounted thereon to engage a belt (16) for climbing or descending with respect thereto, resulting in raising or lowering of an elevator car (12) coupled to said counterweight-drive assembly (24) via the same belt (16).</p> 		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China			PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LJ	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

## BELT-CLIMBING ELEVATOR HAVING DRIVE IN COUNTERWEIGHT AND COMMON DRIVE AND SUSPENSION ROPE

### Technical Field

5

The present invention relates to elevator systems and, more particularly, to an elevator system requiring less installation and operation space than conventional elevator systems by utilizing combined function structures including a counterweight-drive assembly and a belt that shares  
10 drive belt and suspension rope functions.

### Background of the Invention

Known elevator systems typically confine all elevator components to  
15 the hoistway or the machine room. The hoistway is an elongated, vertical shaft having a rectangular base in which the elevator car translates. The hoistway houses, among other things, the car guide rails which are usually a pair of generally parallel rails, fixed to opposite walls near the center of each wall, and running the approximate length of the hoistway. A counterweight  
20 having a pair of guide rails is positioned adjacent to a third wall. The hoistway houses additional components including terminal landing switches, ropes and sheave arrangements, and buffers for the counterweight and the car.

It is essential that the elevator components are located and oriented with precision prior to and during operation. The interior walls of the  
25 hoistway must be properly dimensioned and aligned, and the physical interface between the hoistway walls and the elevator components must be capable of withstanding varying load during use. It is particularly essential that the guide rails on which the car rides are properly positioned and solidly maintained. For quality of ride and safety, the guide rails need to be precisely  
30 plumb, square and spaced to avoid car sway, vibration and knocking. Guide

rails are typically steel, T-shaped sections in sixteen foot lengths. The position of guide rails within the hoistway affects the position of the hoisting machine, governor and overhead (machine room) equipment. The machine room is typically located directly above the hoistway. The machine room houses the hoist machine and governor, the car controller, a positioning device, a motor generator set, and a service disconnect switch.

Because the various components of the hoistway and machine room require precise positioning and they produce varying and substantial loads, it is costly and complicated to assemble a typical traction elevator system.

#### Objects and Summary of the Invention

It is an object of the present invention to provide an improved elevator system that optimizes use of space by providing a multi-function component that functions as a counterweight and a support for the drive machine and system, so that the need for a machine room and other space-consuming components is eliminated. It is a further object to provide an improved elevator system that achieves optimum efficiency in construction and materials by various means including, for example, providing a counterweight apparatus that stores potential energy as an integral part of the lift arrangement and that reduces the required torque for movement of the elevator car. It is a further object of the present invention to provide an elevator system having a self-climbing counterweight-drive assembly that uses a common, shared belt for the drive belt and for suspending the elevator car.

The present invention achieves the aforementioned and other objects by utilizing an assembly of a drive machine and components housed within and moveable with a counterweight, as well as a shared rope or belt which functions both as a drive belt and as a suspension rope. The counterweight-drive assembly includes a motor and drive pulley sized to maintain a narrow

profile and to be suspended and to move in coordination with an elevator car. The use of flat ropes or belts reduces the size of the traction sheave and motor required such that the machine can have a narrow profile, enabling a machine-counterweight assembly to fit between the elevator car and the hoistway wall.

5 As used herein, the term "flat ropes" refers to ropes or belts having an aspect ratio of greater than one, where aspect ratio is defined as the ratio of the rope or belt width to the thickness. The counterweight-drive assembly is coupled to an elevator car by being suspended from the same belt or rope which is fixed

10 drive pulley, the counterweight-drive assembly is caused to climb the belt and move up or down the hoistway. It is preferable to use a flat belt or rope for optimum traction and low weight.

#### Brief Description of the Drawings

15

Fig. 1 is a schematic view of the present invention elevator assembly showing the elevator car and the counterweight drive assembly at a common height.

Fig. 2 is a schematic view of the elevator assembly as shown in Fig. 1 showing the elevator car in a lowered position and the counterweight-drive assembly in a raised position.

20

Fig. 3 is a schematic view of a component of the elevator assembly of Fig. 1 showing the elevator car in a raised position and the counterweight-drive assembly in a lowered position.

25 Fig. 4 is a sectional, side view of a traction sheave and a plurality of flat ropes, each having a plurality of cords.

Fig. 5 is a sectional view of one of the flat ropes.

## Description of the Preferred Embodiments

An elevator assembly according to the present invention is illustrated schematically in Figs. 1-3. An elevator assembly (10) includes an elevator car (12) and a counterweight-drive assembly (14), each being suspended from a belt (16) which is fixed at first (18) and second (20) ends to a hoistway ceiling surface (22) or other fixed structure. The counterweight-drive assembly (14) comprises a body (24) housing a drive assembly (not shown) including a motor. Components of the drive assembly include a drive pulley (26) adapted to provide torque from the motor, and a brake mechanism (28). The motor (not shown) can be an electric motor and can be supplied power and control signals via a power and control cable (30) in communication with a power and control source (32). The cable (30) is adapted to move with the counterweight-drive assembly (24).

The motor (not shown), is preferably of the flat machine type having, for example, a disc-type rotor with the rotational axis of the machine perpendicular to the width of the counterweight. The use of flat ropes with this type of machine minimizes torque requirements of the motor and therefore minimizes the diameter of the disc-type rotor. This enables the counterweight and machine to fit between the car (12) and the hoistway wall. Alternatively, a cylindrical machine may be used in which the rotational axis is parallel to the width of the counterweight. With this type of motor, the use of flat ropes minimizes the overall volume of the motor required so that it can fit within the space between the car (12) and the hoistway wall.

A first idler pulley (34) is fixed to the hoistway ceiling (22) or other stationary surface and pivotally engages the belt (16). A second idler pulley (36) is fixed to the elevator car (12) and also pivotally engages the belt (16).

In operation, when the motor is energized, torque is transferred through the drive pulley (26) to the belt (16) such that the counterweight-drive assembly (24) will move along and relative to the belt (16). The

counterweight-drive assembly (24) can be stopped and fixed relative to the belt (16) in a selected position by activating the braking mechanism (28). The counterweight-drive assembly (24) will selectively move up or down depending on the direction of rotation of the drive pulley (26).

5           When the counterweight-drive assembly (24) is caused to move toward the first end (18) of the belt (16), as shown in Fig. 2, the length of belt (16) between the drive pulley (26) and the first end (18) is shortened, and the remaining length between the drive pulley (26) and the first idler pulley (34) will shorten to maintain tension in the belt between the first idler pulley (34) and the first end (18). As a result, the length of belt (16) between the first  
10 idler pulley (34) and the second end (20) of the belt (16) will increase as gravity acts on the elevator car (12). After the braking mechanism (28) is applied, the counterweight-drive assembly (24) will stop moving and the elevator car (12) will settle in an equilibrium position as shown.

15           To raise the elevator car (12), as shown in Fig. 3, the counterweight-drive assembly (24) is caused to move away from the first end (18) of the belt (16). The length of belt (16) between the drive pulley (26) and the first end (18) is increased and, due to gravity, the counterweight-drive assembly (24) will lower. As a result, the length between the drive pulley (26) and the first  
20 idler pulley (34) will also increase as the belt (16) passes freely over the first idler pulley (34). At the same time, the length of belt (16) between the first idler pulley (34) and the second end (20) of the belt (16) will decrease and cause the elevator car (12) to be raised. After the braking mechanism (28) is applied, the counterweight-drive assembly (24) will stop moving and the  
25 elevator car (12) will settle in an equilibrium position as shown.

          It is understood that while the preferred embodiment contemplates the belt (16) being a flat one for high traction, the belt may be of a variety of different suitable types including a toothed belt. Furthermore, the configuration of the drive mechanism contained in the counterweight-drive  
30 assembly (24) may vary in such ways as using a plurality of motors or drive

pulleys or sheaves. Other modifications of similar type can be implemented in the present invention without departing from the scope of what is presently claimed.

A principal feature of the present invention is the flatness of the ropes used in the above described elevator system. The increase in aspect ratio results in a rope that has an engagement surface, defined by the width dimension "w", that is optimized to distribute the rope pressure. Therefore, the maximum rope pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness "t1" of the flat rope (see Figure 5) may be reduced while maintaining a constant cross-sectional area of the portions of the rope supporting the tension load in the rope.

As shown in Figure 4 and 5, the flat ropes 722 include a plurality of individual load carrying cords 726 encased within a common layer of coating 728. The coating layer 728 separates the individual cords 726 and defines an engagement surface 730 for engaging the traction sheave 724. The load carrying cords 726 may be formed from a high-strength, lightweight non-metallic material, such as aramid fibers, or may be formed from a metallic material, such as thin, high-carbon steel fibers. It is desirable to maintain the thickness "d" of the cords 726 as small as possible in order to maximize the flexibility and minimize the stress in the cords 726. In addition, for cords formed from steel fibers, the fiber diameters should be less than .25 millimeters in diameter and preferably in the range of about .10 millimeters to .20 millimeters in diameter. Steel fibers having such diameter improve the flexibility of the cords and the rope. By incorporating cords having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the flat ropes, the traction sheave diameter "D" may be reduced while maintaining the maximum rope pressure within acceptable limits.

The engagement surface 730 is in contact with a corresponding surface 750 of the traction sheave 724. The coating layer 728 is formed from a polyurethane material, preferably a thermoplastic urethane, that is extruded onto and through the plurality of cords 726 in such a manner that each of the individual cords 726 is restrained against longitudinal movement relative to the other cords 726. Other materials may also be used for the coating layer if they are sufficient to meet the required functions of the coating layer: traction, wear, transmission of traction loads to the cords and resistance to environmental factors. It should be understood that although other materials may be used for the coating layer, if they do not meet or exceed the mechanical properties of a thermoplastic urethane, then the benefits resulting from the use of flat ropes may be reduced. With the thermoplastic urethane mechanical properties the traction sheave 724 diameter is reducible to 100 millimeters or less.

As a result of the configuration of the flat rope 722, the rope pressure may be distributed more uniformly throughout the rope 722. Because of the incorporation of a plurality of small cords 726 into the flat rope elastomer coating layer 728, the pressure on each cord 726 is significantly diminished over prior art ropes. Cord pressure is decreased at least as  $n^{-1/2}$ , with  $n$  being the number of parallel cords in the flat rope, for a given load and wire cross section. Therefore, the maximum rope pressure in the flat rope is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity. Furthermore, the effective rope diameter 'd' (measured in the bending direction) is reduced for the equivalent load bearing capacity and smaller values for the sheave diameter 'D' may be attained without a reduction in the D/d ratio. In addition, minimizing the diameter D of the sheave permits the use of less costly, more compact, high speed motors as the drive machine.

A traction sheave 724 having a traction surface 750 configured to receive the flat rope 722 is also shown in Figure 4. The engagement surface 750 is complementarily shaped to provide traction and to guide the

engagement between the flat ropes 722 and the sheave 724. The traction sheave 724 includes a pair of rims 744 disposed on opposite sides of the sheave 724 and one or more dividers 745 disposed between adjacent flat ropes. The traction sheave 724 also includes liners 742 received within the  
5 spaces between the rims 744 and dividers 745. The liners 742 define the engagement surface 750 such that there are lateral gaps 754 between the sides of the flat ropes 722 and the liners 742. The pair of rims 744 and dividers, in conjunction with the liners, perform the function of guiding the flat ropes 722 to prevent gross alignment problems in the event of slack rope conditions, etc.  
10 Although shown as including liners, it should be noted that a traction sheave without liners may be used.

As can be seen from the foregoing description of the preferred embodiment, the present invention eliminates the need for a machine room, requires less total material, and enables use of small diameter drive pulley and  
15 idler pulleys with a high-traction flat rope or belt. The machine or drive assembly (24) can be accessed either from the bottom of the hoistway or through a window or opening in the elevator car (12) when positioned in alignment. The design of the present invention eliminates body-conducted vibrations and noise from the motor to the car (12) or building. The flat belt  
20 (16) inherently dampens vibrations. The counterweight-drive assembly (24) may be pre-assembled and pre-tested to save on installation time and to increase reliability.

## The Claims

## WHAT IS CLAIMED IS :

- 1) An elevator system comprising
  - 5                   a belt having at least one end fixed relative to an elevator hoistway ;  
                  a counterweight-drive assembly suspended by said belt and having drive means for engaging said belt in traction and driving said counterweight-drive assembly relative to said belt ; and
  - 10                an elevator car suspended by said belt and having belt engaging means for engaging said belt,  
                  whereby when said counterweight-drive assembly is driven relative to said belt, said elevator car is moved in response thereto.
- 15   2. An elevator system according to claim 1, wherein  
          said belt engaging means comprise at least one idler pulley fixed to said elevator car and adapted to receive said belt.
3. An elevator system according to claim 1, wherein  
20           said belt is a flat rope.
4. An elevator system according to claim 1, wherein  
          said drive means include an electric motor and a traction drive pulley.

25

5. An elevator system according to claim 1, wherein  
said drive means include a braking member for selectively  
braking said traction drive pulley relative to said belt.
- 5 6. An elevator system comprising  
a rope havng at least one end fixed relative to an elevator  
hoistway ;  
a counterweight-drive assembly having drive means for  
engaging said rope in traction and driving said counterweight-drive  
10 assembly relative to said rope ; and  
an elevator car having rope engaging means for engaging said  
rope,  
whereby when said counterweight-drive assembly is driven  
relative to said rope, said elevator car is moved in response thereto.
- 15 7. An elevator system according to claim 6, wherein  
said rope is a flat rope.
8. An elevator system according to claim 6, wherein  
20 said rope engaging means comprises an idler pulley.
9. An elevator system according to claim 6, wherein  
said drive assembly comprises a rotor having a rotational axis  
perpendicular to the width of said counterweight-drive assembly.
- 25

10. An elevator system according to claim 6, wherein  
said drive assembly comprises a rotor having a rotational axis  
parallel to the width of said counterweight-drive assembly.

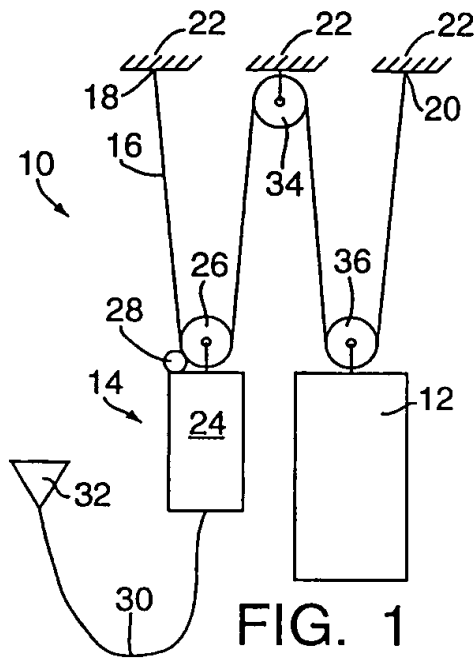


FIG. 1

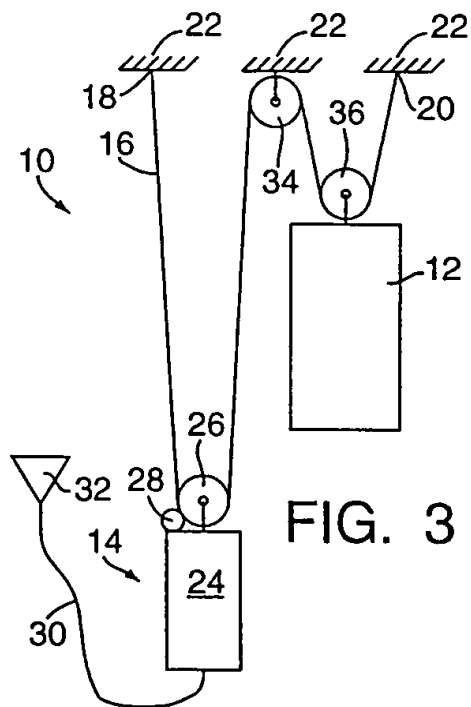


FIG. 3

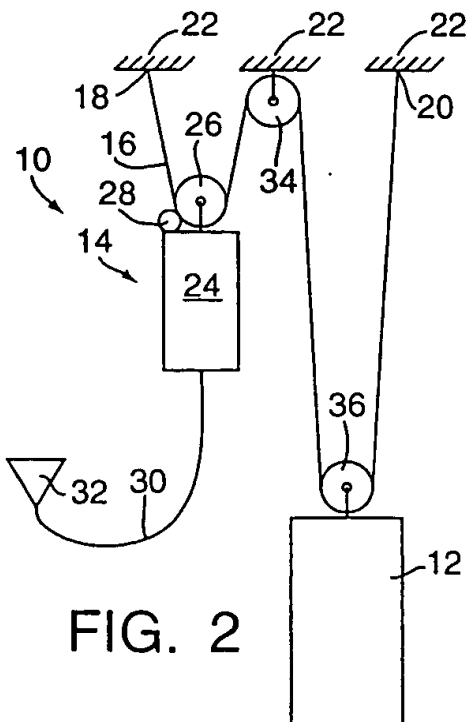


FIG. 2

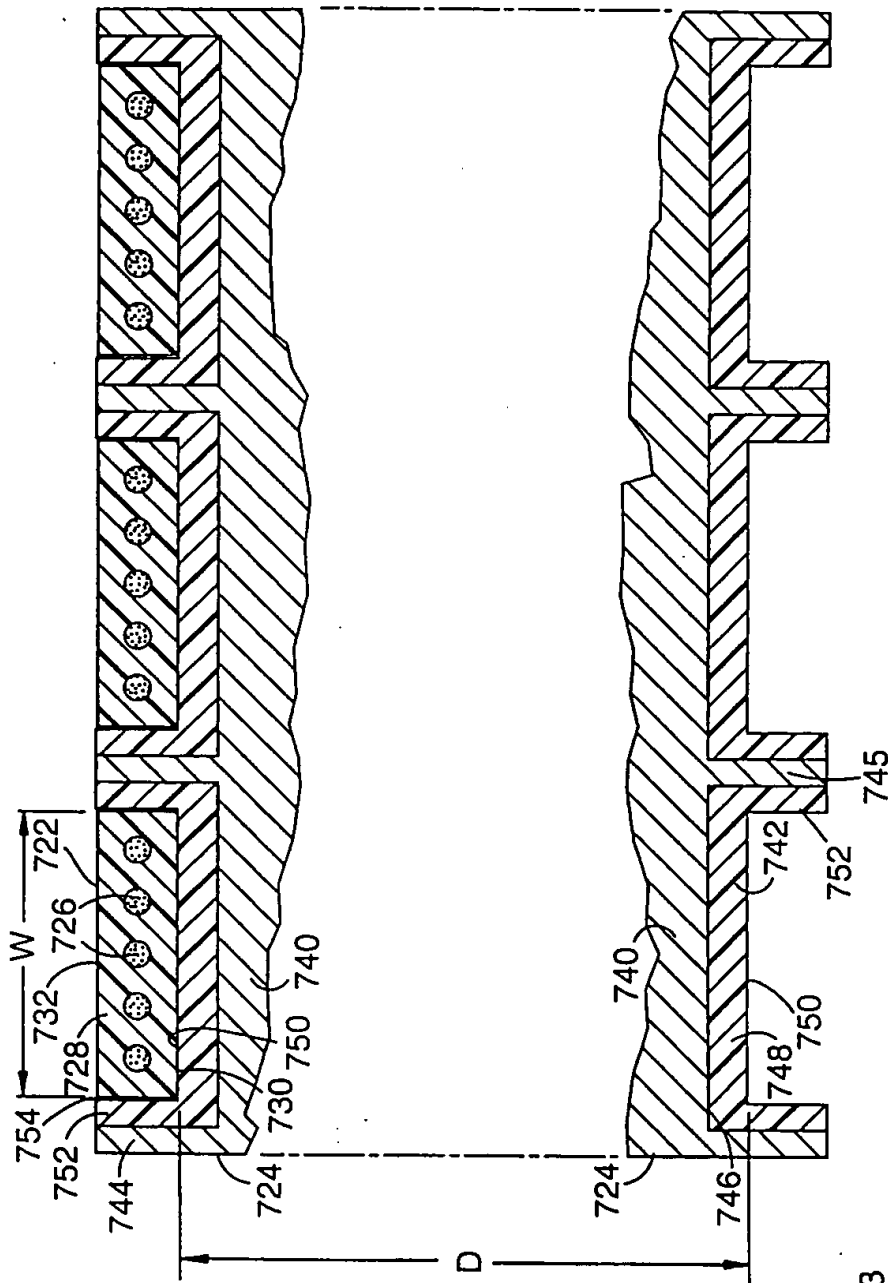


FIG. 4

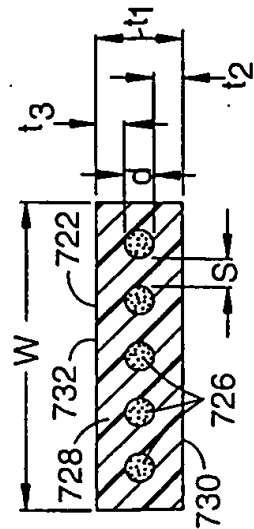


FIG. 5

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/03647

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B66B17/12 B66B11/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	EP 0 631 969 A (KONE OY) 4 January 1995 see abstract see column 3, line 23 - column 4, line 23 see column 1, line 50 - column 2, line 1 ---	6,8,9 1-5,7 10
Y A	DE 23 33 120 A (VOGEL RUDOLF DR ING) 23 January 1975 see the whole document -----	1-5,7 6

☐ Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

### \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

24 June 1999

Date of mailing of the international search report

01/07/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Salvador, D

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/03647

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0631969 A	04-01-1995	FI 932972 A	29-12-1994
		AU 679984 B	17-07-1997
		AU 6595494 A	05-01-1995
		BR 9402575 A	14-03-1995
		CA 2126583 A,C	29-12-1994
		CN 1103050 A,B	31-05-1995
		JP 7137963 A	30-05-1995
		RU 2071931 C	20-01-1997
		US 5566785 A	22-10-1996
DE 2333120 A	23-01-1975	NONE	